The Impact of Stressors on Honey Bees

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Introduction

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Background: Why study honey bees

Ecological

- Support biodiversity
- Established relationship between the diversity of plants and pollinator species. Greater pollinator diversity = greater plant diversity and vice versa.
- Apis mellifera is the most frequent floral visitor in natural habitats worldwide, averaging 13% of floral visits across all networks, with 5% of plant species recorded as being exclusively visited by A. mellifera. → global meta-analysis
- An estimated 87.5% of flowering plant species are pollinated by animals

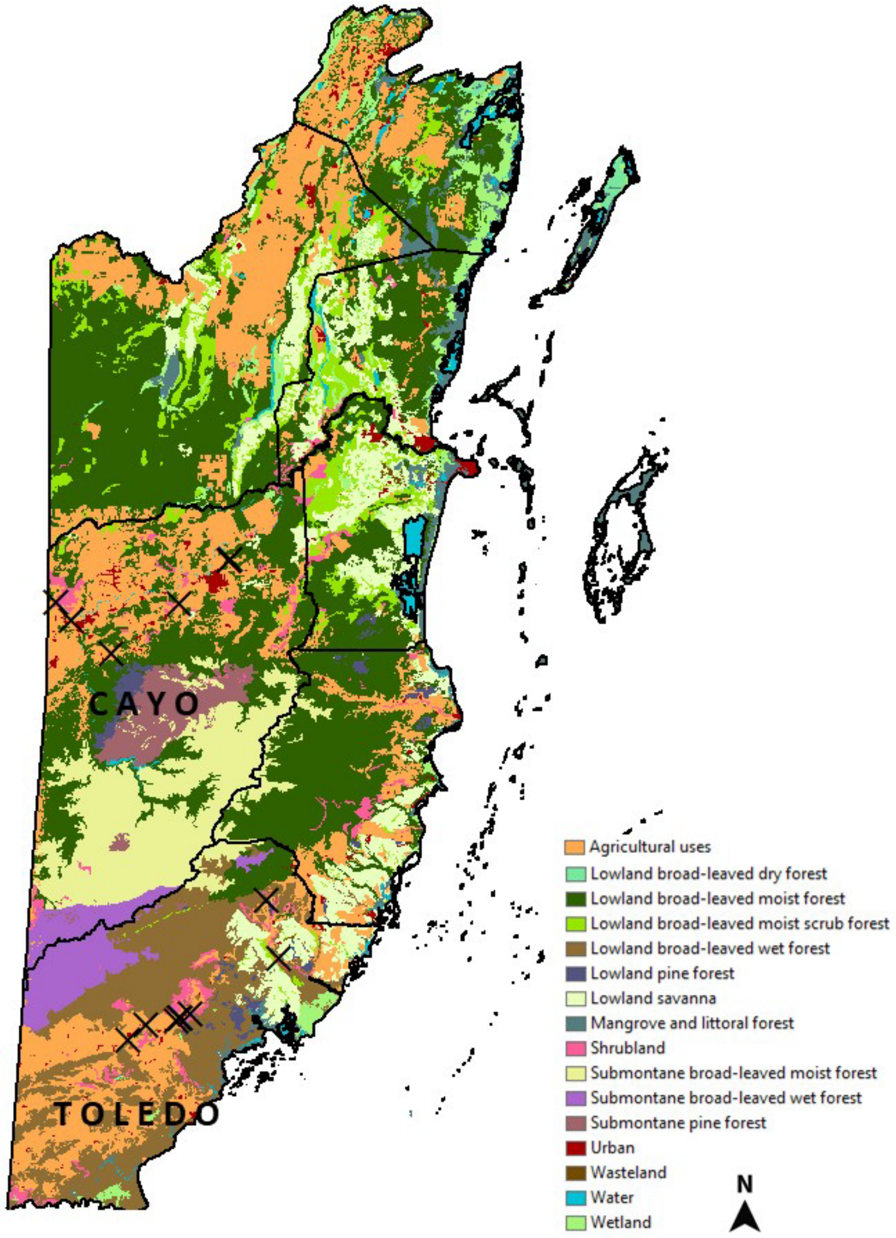
Socioeconomic

- Honeybees, mainly *Apis mellifera*, remain the most economically valuable pollinators of crop monocultures worldwide.
- Crop production and food security → 35% benfit from insect pollination
- Potential to ensure livelihood security and alleviate poverty among rural communities.
- Beekeeping practises and honey production based on local and indigenous knowledge have been documents in more than 50 countries worldwide.
- Opportunities for small rural villages as practices typically:
  - Require minimal investment
  - Generate diverse saleable products
  - Occur without land ownership or rent
  - Provide family nutrition and medicinal benefits
  - Further products can be created with minimal processing such as candles from the collected wax, or mead from honey production.

Background: Study Site

Central America: Belize

- Lack of research of stressors on bees in tropical regions compaired temperate regions
- Belize is the only country remaining in Central America where there is still over 60% forest cover – predicted to be below 50% by 2045 if current rates continue.
- Current move away from subsistence farming to intensive agriculture
- Apiculture is very important to subsidise incomes – particularly for Mayan communities in the South.

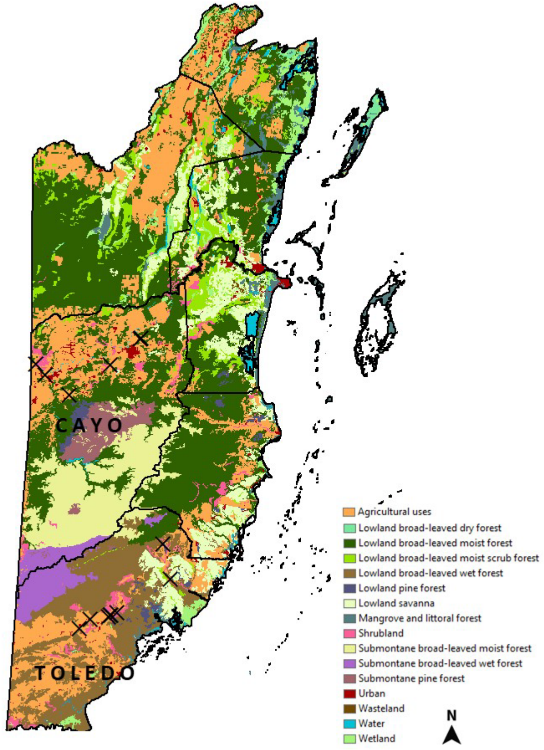


The impact of landscape on honey bee pollen diet: Background

- Honey bees forage on flowering plants as their primary source of nutrition.
- Obtain: proteins, amino acids, vitamins, carbohydrates, lipids.
- 10 essential amino acids: arginine, histidine, lysine, tryptophane, phenylalanine, methionine, threonine, leucine, isoleucine, and valine (De Groot, 1953).
- It has been recommended that crude protein levels are above 25% in order to satisfy colony requirements (Somerville and Nicol, 2006).
- Malnutrition of pollen in bees has been shown to lead to **smaller hypopharyngeal glands** (HPGs), increased **susceptibility to deformed wing virus**, **parasitism**, particularly by *Nosema ceranae*, and **vulnerability to pesticides**, and a **shorter life span** (Arien et al., 2015).
- Pollen diet is particularly important for larvae, which rely on pollen to sustain normal growth and development (Li et al., 2012).
- Whilst there may be flowering plants in the surrounding landscapes not all plants provide the same quantities and qualities of these nutrients – potential variation with land use.

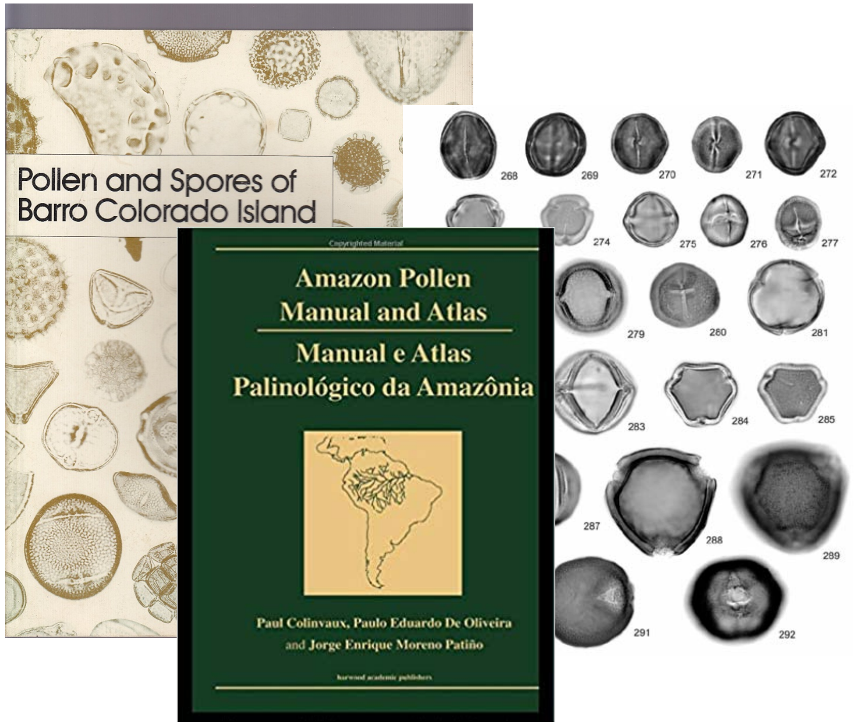
Methodology: Pollen Collection

- 14 aipary locations identified across Belize (Cayo and Toledo District)
- Ideally 4 hives sampled at each aipary
- Total of 46 hives
- Bee bread collected from each hive (50 cells) – take from last frame of brood box.
- Stored in sampled tubes with silica gel



Methodology: Pollen Identification

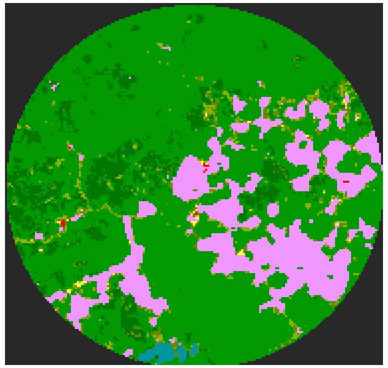
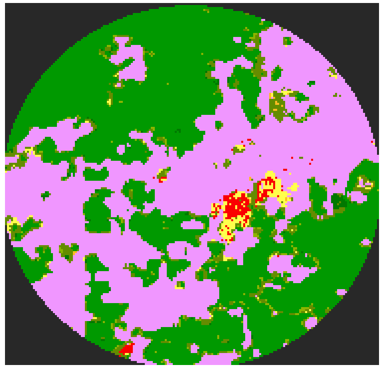
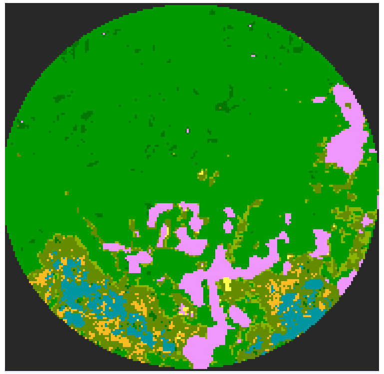
- Each hive sample mannually homogenised into 3 sub samples of 0.25 g
- Acetolysis procedure used to extract pollen grains
- Samples mounted to slides with gycerine jelly
- 500 pollen grains counted per slide – 1500 grains per sample



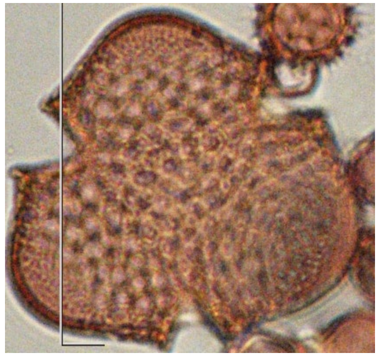
Methodology: Land use mapping

- Determining the land use types surrounding each apiary site
- 500m, 1km, 2km, 10km radius
- Belize land use map (J.C. Meerman) - LANDSAT remote sensing data (30-m spatial resolution)
- Calculated landscape composition and configuration metrics for each buffer radii:
    - Percentage forest
    - Percentage Agriculture
    - Forest Edge
    - Agricultural Edge
    - Average Patch Size
    - Landscape Diversity (Shannons)

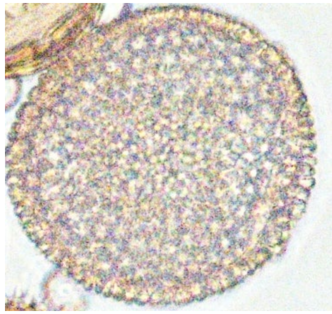
- A model-selection framework was used to assess to most appropriate and parsimonious models.
- Run including all landscape metrics at each radii, with and without interactions.
- Models were compared using automated AIC selection. Only models with substantial support ($\Delta AICc < 2$) were considered.

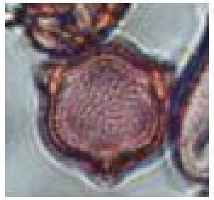
Results: Pollen Taxa



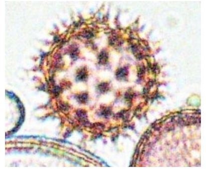
- Malvaceae
- *Pseudobombax ellipticum*



- Euphorbiaceae
- *Croton sp*

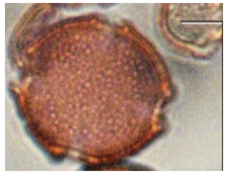


- Burseraceae
- *Bursera simaruba*



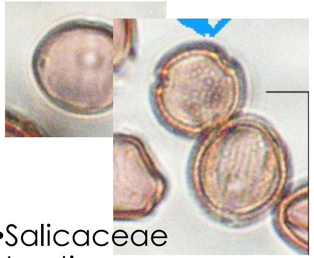
- Asteraceae

- Arecaceae
- *Attalea sp*

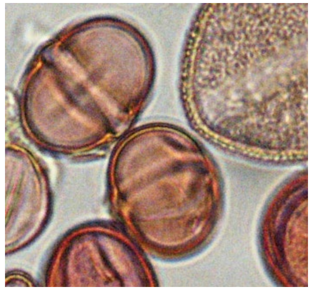


- Rutaceae
- *Citrus sp*

- Anacardiaceae

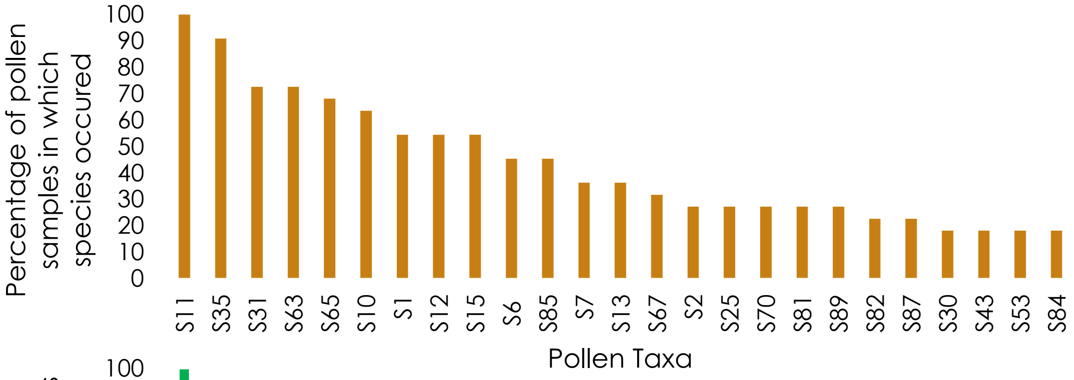


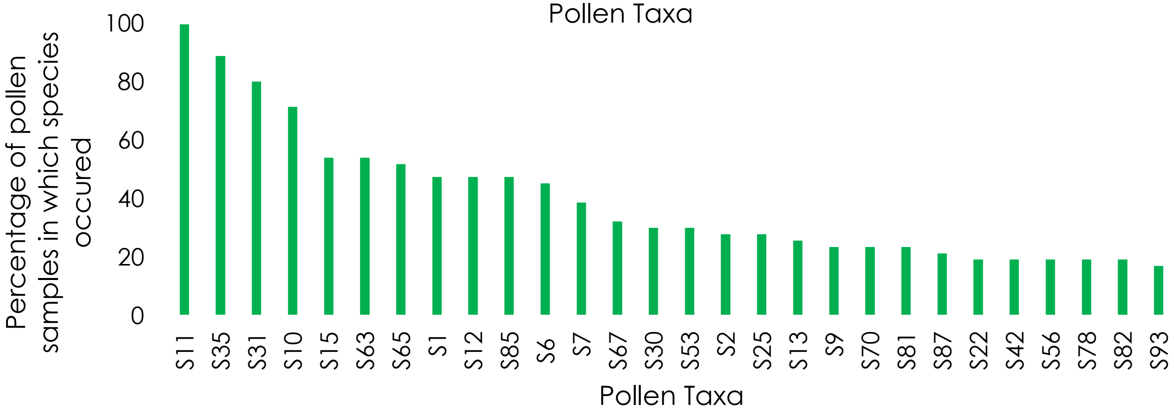
- Salicaceae
- *Laetia sp*



- Burseraceae

Results: Most common pollen taxa





The percentage of pollen samples in which each species occurred in forest and agricultural sites. Species which occurred in over 15% of samples included.

•**S65** Anacardiaceae

•**S11** Arecaceae
•*Attalea sp*

•**S15** Salicaceae
•*Laetia sp*

•**S35** Uritaceae
•*Cercropia sp*

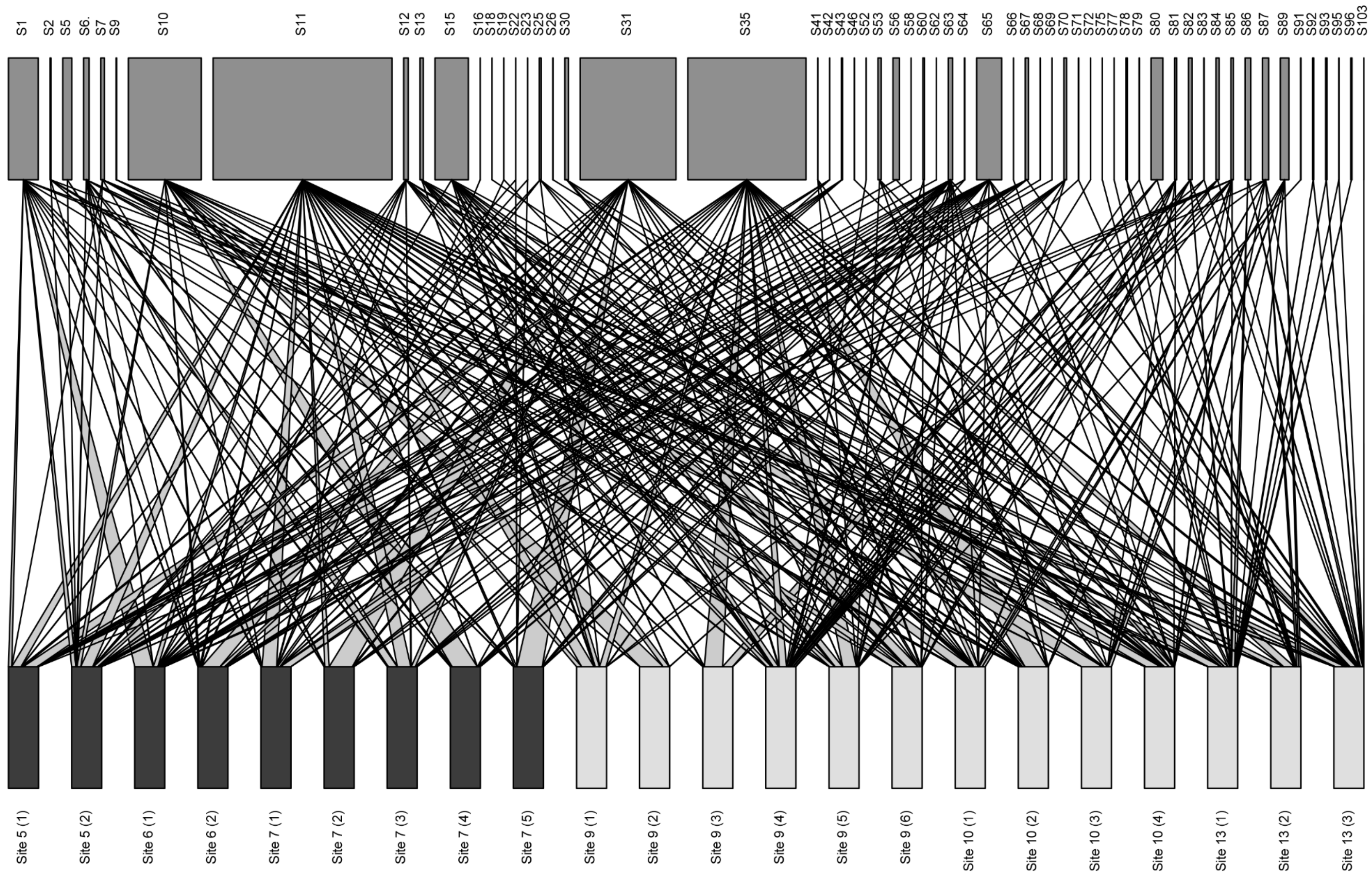
Results: Pollen taxa networks- Forest

KEY DIFFERENCES:

- Connectance = 0.205
- H2 = 0.445
- Mean links per hive = 15.8
- Most connected species = S11, S35, S10,

Toledo Cayo

FOREST: Bipartite graph showing the proportion of trophic interactions between A.M. scutellata hives in the Toledo and Cayo districts of Belize, and the prominent, secondary, and important minor pollen types present in bee bread. Interactions which made up less than 3% (minor pollen grains) of the hives interactions have been removed in order to improve the clarity of interactions.

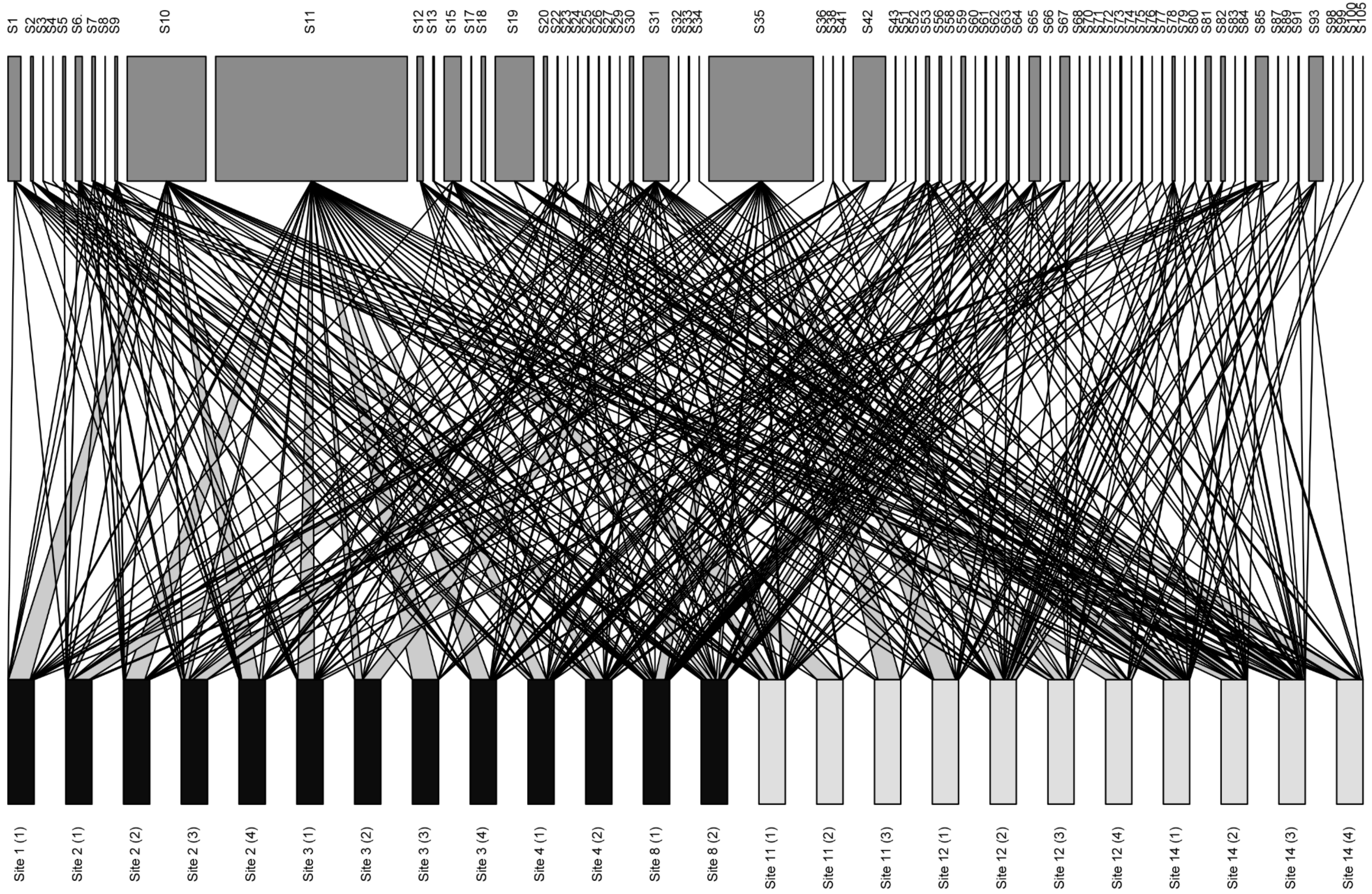


Results: Pollen taxa networks- Agriculture

- KEY DIFFERENCES:
  - Connectance = 0.227
  - H2 = 0.349
  - Mean links per hive = 13.6
  - Most connected species = S11, S35, S31, S10, S15

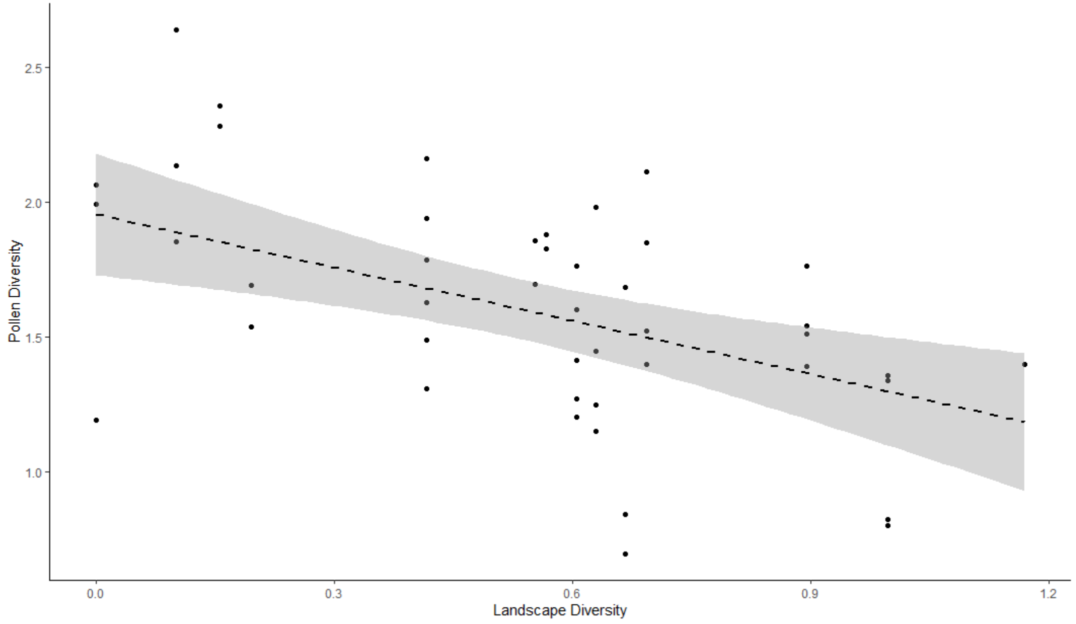
Toledo Cayo

AGRICULUTRE: Bipartite graph showing the proportion of trophic interactions between A.M. scutellata hives in the Toledo and Cayo districts of Belize, and the prominent, secondary, and important minor pollen types present in bee bread. Interactions which made up less than 3% (minor pollen grains) of the hives interactions have been removed in order to improve the clarity of interactions.



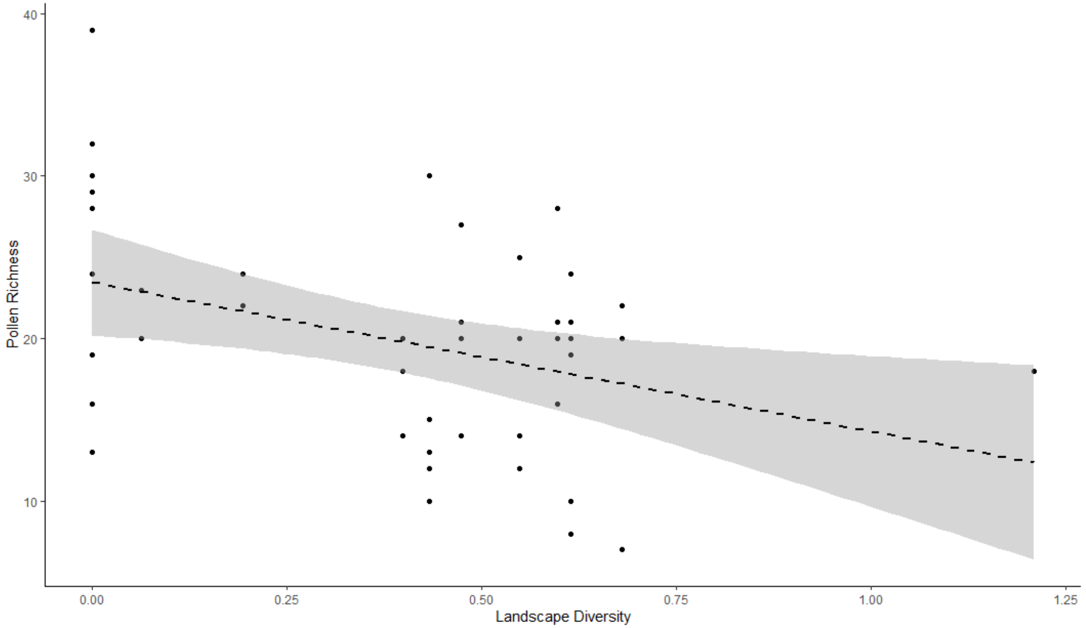
Results: Landscape diversity negatively impacts pollen richness and diversity

Within 1-km of hives - the landscape diversity significantly reduced the diversity (Shannons) of pollen taxa found in beebread ($t = -2.88$, $df = 41$, $p = 0.014$).



Impact of landscape diversity on pollen diversity (1-km buffer radii)

Within 500-m of hives - the landscape diversity significantly reduced the diversity (Shannons) of pollen taxa found in beebread ($t = -2.66$, $df = 41$, $p = 0.007$).



Impact of landscape diversity on pollen species richness (500-m buffer radii)

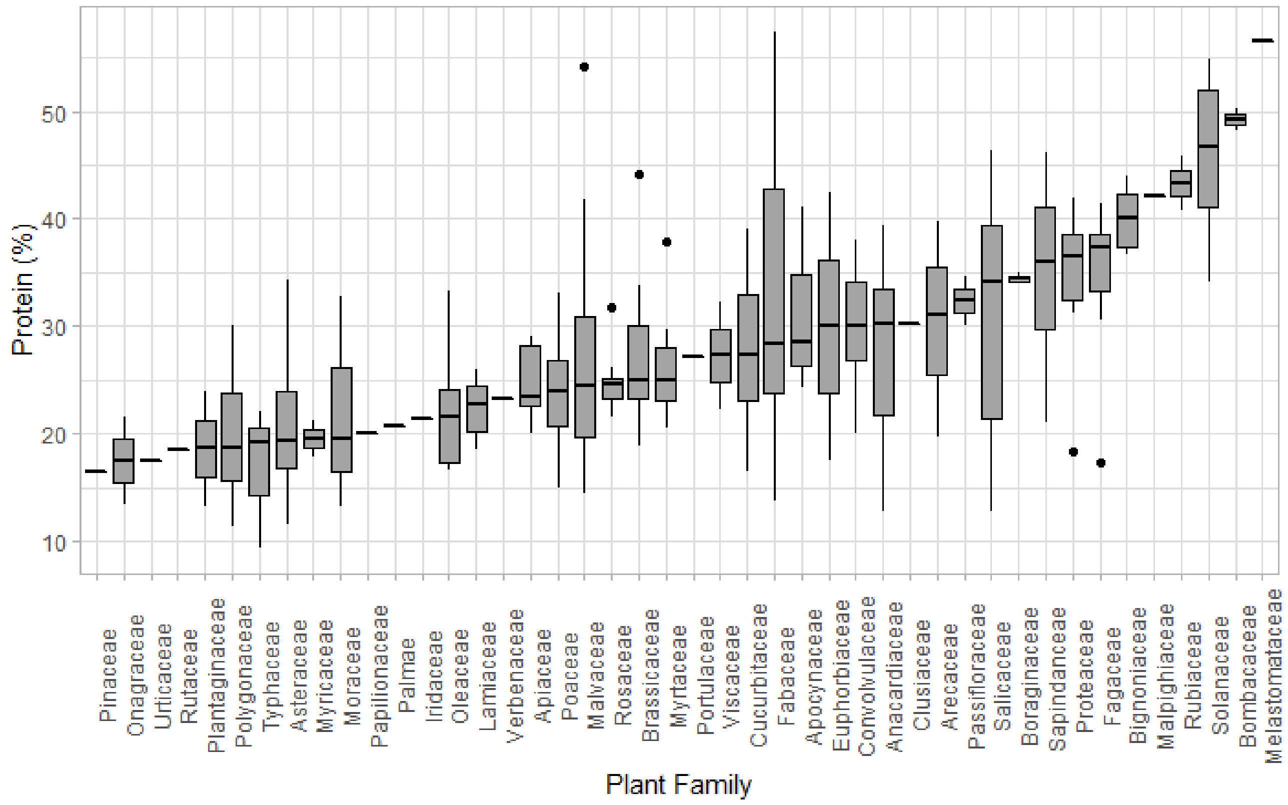
Results: Pollen nutrition across landscape gradients

- Future analysis

- Model comparing pollen species richness and abundances with percentage forest.

- GLMER
- Species richness ~ percentage forest * location * Date (random effect)

- Link betweeen diverity and fitness
- Use median crude protein levels as a proxy for nutrition content.
- Percentate crude protein per hive as output.



Crude protein content per plant family.

Discussion

- The Africanised honey bee has strong preferences towards just a few pollen taxa.
- Importance of trees, such as Cohune, Gumbolimbo, Cecropia etc.
- View differences is species found in forested and agricultural landscapes – majority are tree species - suggesting that forests are very import for bee foraging.
- Lower landscape diversity causes increase pollen diveristy and species richness – against points to the importance of forest – tree taxa in pollen samples.
- Conservation of forest important for the Africansed honey bee.

Thank you

Questions ?

Sustainable Infrastructure Systems

UNIVERSITY OF Southampton